malaria in a concentrated form; that if there is a thick screen of primeval forest or a grove of plantains between the dwelling-place and a large clearing or open country there is only danger of the local malaria around the dwelling, which might be rendered harmless by the slightest attention to the system; but in the open country neither a house nor a tent is sufficient protection, since the air enters by the doors of the house, and under the flaps, and through the ventilators to poison the inmates.

"Hence we may infer that trees, tall shrubbery, a high wall or close screen interposed between the dwelling-place and the wind currents will mitigate their malarial influence, and the inmate will only be subjected to local exhalations.

"Emin Pasha informed me that he always took a mosquito curtain with him, as he believed that it was an excellent protector against miasmatic exhalations of the night.

"Question, might not a respirator attached to a veil, or face screen of muslin, assist in mitigating malarious effects when the traveller finds himself in open regions?"

As a matter of fact, we believe a veil or a mosquito curtain is found a useful preventive in malarial regions.

Mr. Stanley gives some natural history notes which he obtained from Emin. Here, for example, is a statement which he gives in Emin's own words, but which notwithstanding is somewhat astounding:—

"The forest of Msongwa is infested with a large tribe of chimpanzees. In summer-time, at night, they frequently visit the plantations of Mswa Station to steal the fruit. But what is remarkable about this is the fact that they use torches to light the way! Had I not witnessed this extraordinary spectacle personally, I should never have credited that any of the Simians understood the art of making fire.

"One of these same chimpanzees stole a native drum from the station, and went away pounding merrily on it. They evidently delight in that drum, for I have frequently heard them rattling away at it in the silence of the night."

The importance of this fact with regard to fire-using (it is not stated that they are fire-making) chimpanzees need not be pointed out. We cannot doubt the accuracy of Mr. Stanley's report, nor the trustworthiness of Emin's observation; but we should like to have more details.

Great expectations have been formed of Mr. Stanley's narrative of one of the most remarkable African expeditions on record. These expectations have not been disappointed. The reader who merely seeks for the excitement of adventure will find what he seeks in almost every page. We have written enough to prove that the student of science and the geographer will find the narrative teeming with novel and suggestive facts. There are no doubt a few marks of haste and fatigue on the part of the author; but the work is altogether worthy of Mr. Stanley's brilliant record, and entitles him, let us once more say, to be ranked among the foremost pioneers of science in "Darkest Africa."

By the courtesy of Messrs. Sampson Low and Co. we are able to give a few specimens of the 150 illustrations which add so much to the beauty and value of the book, which from the point of view of get-up is entirely creditable to all concerned.

J. S. K.

PROBLEMS IN THE PHYSICS OF AN ELECTRIC LAMP.[1]

II.

AT this stage it will perhaps be most convenient to outline briefly the beginnings of a theory proposed to reconcile these facts, and leave you to judge how far the subsequent experiments confirm this hypothesis. The theory very briefly is as follows:—From all parts of the incandescent carbon loop, but chiefly from the negative leg, carbon molecules are being projected which carry with them, or are charged with, negative electricity. I will in a few moments make a suggestion to you which may point to a possible hypothesis on the manner in which the molecules acquire this negative charge. Supposing this, however, to be the case, and that the bulb is filled with these negatively-charged molecules, what would be the result of introducing into their midst a conductor such as this middle metal plate which is charged positively? Obviously, they would all be attracted to it and discharge against it. Suppose the positive charge of this conductor to be continually renewed, and the negatively-charged molecules continually supplied, which conditions can be obtained by connecting the middle plate to the positive electrode of the lamp, the obvious result will be to produce a current of electricity flowing through the wire or galvanometer, by means of which this middle plate is connected to the positive electrode of the lamp. If, however, the middle plate is connected to the negative electrode of the lamp, the negatively-charged molecules can give up no charge to it, and produce no current in the interpolated galvanometer. We see that on this assumption the effect must necessarily be diminished by any arrangement which prevents these negatively-charged molecules from being shot off the negative leg or from striking against the middle plate. Another obvious corollary from this theory is that the "Edison effect" should be annihilated if the metal collecting plate is placed at a distance from the negative leg much greater than the mean free path of the molecules.

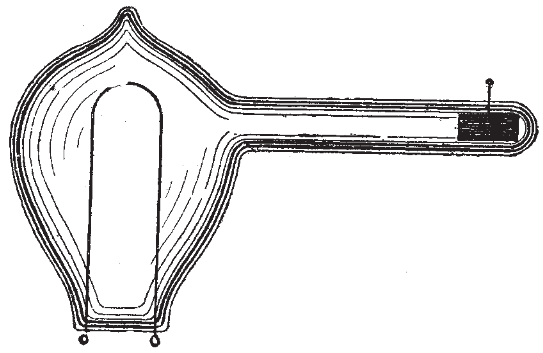

FIG. 8.—Collecting plate placed at end of a tube, 18 inches in length, opening out of the bulb.

Here are some experiments which confirm this deduction. In this bulb (Fig. 8) the metal collecting plate, which is to be connected through the galvanometer with the positive terminal of the lamp, is placed at the end of a long tube opening out of and forming part of the bulb. We find the "Edison effect" is entirely absent, and that the galvanometer current is zero. We have, as it were, placed our target at such a distance that the longest range molecular bullets cannot hit it, or, at least, but very few of them do so. Here again is a lamp in which the plate is placed at the extremity of a tube opening out of the bulb, but bent at right angles (Fig. 9). We find in this case, as first discovered by Mr. Preece, that there is no "Edison effect." Our molecular marksman cannot shoot round a corner. None of the negatively charged molecules can reach the plate, although that plate is placed at a distance not greater than would suffice to produce the effect if the bend were straightened out. Following out our hypothesis into its consequences would lead us to conclude that the material of which the plate is made is without influence on the result, and this is found to be the case. Many of the foregoing facts were established by Mr. Preece as far back as 1885, and I have myself abundantly confirmed his results.

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[1] Friday Evening Discourse delivered at the Royal Institution by Prof. J. A. Fleming, M.A., D.Sc., on February 14, 1890. Continued from p. 201.

We should expect also to find that the larger we make our plate, and the nearer we bring it to the negative leg of the carbon, the greater will be the current produced in a circuit connecting this plate to the positive terminal of the lamp. I have before me a lamp with a large plate placed very near the negative leg of the carbon of a lamp, and we find that we can collect enough current from these molecular charges to work a telegraph relay and ring an electric bell. The current which is now working this relay is made up of the charges collected by the plate from the negatively charged carbon molecules which are projected against it from the negative leg, across the highly perfect vacuum. I have tried experiments with lamps in which the collecting plate is placed in all kinds of positions, and has various forms, some of which are here, and are represented in the diagrams before you; but the results may all be summed up by saying that the greatest effects are produced when the collecting plate is as near as possible to the base of the negative end of the loops, and, as far as possible, incloses, without touching, the carbon conductor. Time will not permit me to make more than a passing reference to the fact that the magnitude of the current flowing through the galvanometer when connected between the middle plate and the positive terminal of the lamp often "jumps" from a low to a high value, or *vice versâ*, in a remarkable manner, and that this sudden change in the current can be produced by bringing strong magnets near the outside of the bulb.

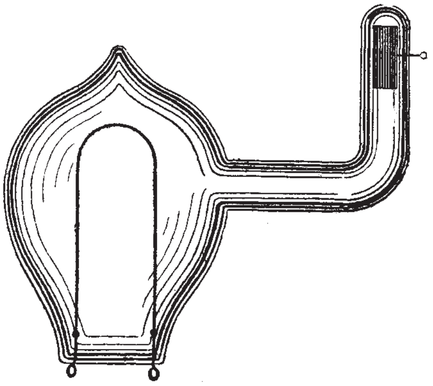

Fig. 9.—Collecting plate placed at end of an elbow tube opening out of the bulb.

Let us now follow out into some other consequences this hypothesis that the interior of the bulb of a glow-lamp when in action is populated by flying crowds of carbon atoms all carrying a negative charge of electricity. Suppose we connect our middle collecting plate with some external reservoir of electric energy, such as a Leyden jar, or with a condenser equivalent in capacity to many hundreds of Leyden jars, and let the side of the condenser which is charged positively be first placed in connection through a galvanometer with the middle plate (see Fig. 10), whilst the negative side is placed in connection with the earth. Here is a condenser of two microfarads capacity so charged and connected. Note what happens when I complete the circuit and illuminate the lamp by passing the current through its filament. The condenser is at once discharged. If, however, we repeat the same experiment with the sole difference that the negatively charged side of the condenser is in connection with the middle plate then there is no discharge. The experimental results may be regarded from another point of view. In order that the condenser may be discharged as in the first case, it is essential that the negatively charged side of the condenser shall be in connection with some part of the circuit of the incandescent carbon loop. This experiment with the condenser discharged by the lamp may be then looked upon as an arrangement in which the plates of a charged condenser are connected respectively to an incandescent carbon loop and to a cool metal plate, both being inclosed in a highly vacuous space, and it appears that when the incandescent conductor is the negative electrode of this arrangement the discharge takes place, but not when the cooler metal plate is the negative electrode of the charged condenser. The negative charge of the condenser can be carried across the vacuous space from the hot carbon to the colder metal plate, but not in the reverse direction.

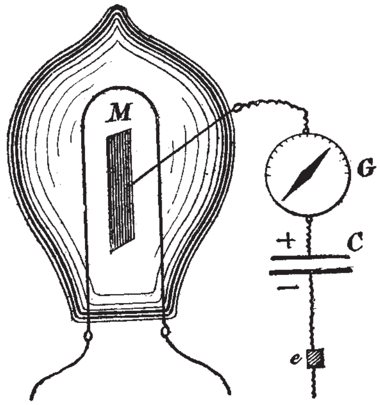

Fig. 10.—Charged condenser C discharged by middle plate M, when the positively charged side of condenser is in connection with the plate and other side to earth *e*.

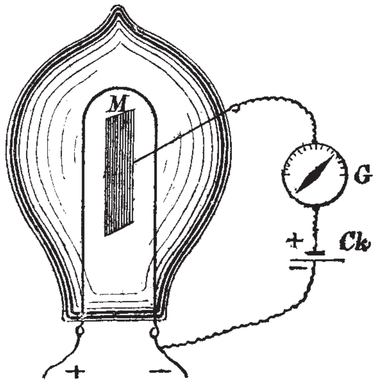

Fig. 11.—Current from Clark cell *Ck* being sent across vacuous space between negative leg of carbon and middle plate M. Positive pole of cell in connection with plate M through galvanometer G.

This experimental result led me to examine the condition of the vacuous space between the middle metal plate and the negative leg of the carbon loop in the case of the lamp employed in our first experiment. Let us return for a moment to that lamp. I join the galvanometer between the middle plate and the negative terminal of the lamp, and find, as before, no indication of a current. The metal plate and the negative terminal of the lamp are at the same electrical potential. In the circuit of the galvanometer we will insert a single galvanic cell having an electromotive force of rather over one volt. In the first place let that cell be so inserted that its negative pole is in connection with the middle plate, and its positive pole in connection through the galvanometer with the negative terminal of the lamp (see Fig. 11). Regarding the circuit of that cell alone, we find that it consists of the cell itself, the galvanometer wire, and that half-inch of highly vacuous space between the hot carbon conductor and the middle plate. In that circuit the cell cannot send any sensible current at all, as it is at the present moment connected up. But if we reverse the direction of the cell so that its positive pole is in connection with the middle plate, the galvanometer at once gives indications of a very sensible current. This highly vacuous space, lying between the middle metal plate on the one hand, and the incandescent carbon on the other, possesses a kind of unilateral conductivity, in that it will allow the current from a single galvanic cell to pass one way but not the other. It is a very old and familiar fact that in order to send a current from a battery through a highly rarefied gas by means of metal electrodes, the electromotive force of the battery must exceed a certain value. Here, however, we have indication that if the negative electrode by which that current seeks to enter the vacuous space is made incandescent the current will pass at a very much lower electromotive force than if the electrode is not so heated.

A little consideration of the foregoing experiments led to the conclusion that in the original experiment, as devised by Mr. Edison, if we could by any means render the middle plate very hot, we should get a current flowing through a galvanometer when it is connected between the middle plate and the negative electrode of the carbon. This experiment can be tried in the manner now to be shown. Here is a bulb (Fig. 12) having in it two carbon loops; one of these is of ordinary size, and will be rendered incandescent by the current from the mains. The other loop is very small, and will be heated by a well-insulated secondary battery. This smaller incandescent loop shall be employed just as if it were a middle metal plate. It is, in fact, simply an incandescent middle conductor. On repeating the typical experiment with this arrangement, we find that the galvanometer indicates a current when connected between the middle loop and either the positive *or* the negative terminal of the main carbon. I have little doubt but that if we could render the platinum plate in our first-used lamp incandescent by concentrating on it from outside a powerful beam of radiant heat we should get the same result.

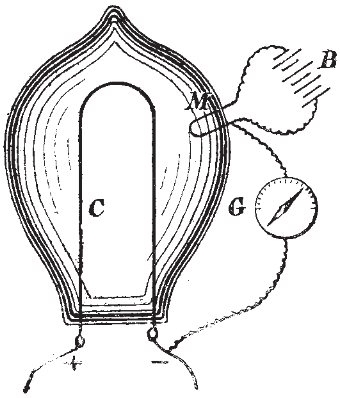

FIG. 12.—Experiment showing that when the "middle plate" is a carbon loop rendered incandescent by insulated battery B, a current of negative electricity flows from M to the positive leg of main carbon C across the vacuum.

A similar set of results can be arrived at by experiments with a bulb constructed like an ordinary vacuum tube, and having small carbon loops at each end instead of the usual platinum or aluminium wires. Such a tube is now before you (see Fig. 13), and will not allow the current from a few cells of a secondary battery to pass through it when the carbon loops are cold. If, however, by means of well-insulated secondary batteries we render both of the carbon loop electrodes highly incandescent, a single cell of a battery is sufficient to pass a very considerable current across that vacuous space, provided the resistance of the rest of the circuit is not large. We may embrace the foregoing facts by saying that if the electrodes, but especially the negative electrode, which form the means of ingress and egress of a current into a vacuous space are capable of being rendered highly incandescent, and if at that high temperature they are made to differ in electrical potential by the application of a very small electromotive force, we may get under these circumstances a very sensible current through the rarefied gas. If the electrodes are cold a very much higher electromotive force will be necessary to begin the discharge or current through the space. These facts have been made the subject of elaborate investigation by Hittorf and Goldstein, and more recently by Elster and Geitel. It is to Hittorf that I believe we are indebted for the discovery of the fact that by heating the negative electrode we greatly reduce the apparent resistance of a vacuum.

Permit me now to pave the way by some other experiments for a little more detailed outline of the manner in which I shall venture to suggest these negative molecular charges are bestowed. This is really the important matter to examine. In seeking for some probable explanation of the manner in which these wandering molecules of carbon in the glow-lamp bulb obtain their negative charges, I fall back for assistance upon some facts discovered by the late Prof. Guthrie. He showed some years ago new experiments on the relative powers of incandescent bodies for retaining positive and negative charges. One of the facts he brought forward[1] was that a bright red-hot iron ball, well insulated, could be charged negatively, but could not retain for an instant a positive charge. He showed this fact in a way which it is very easy to repeat as a lecture experiment. Here is a gold-leaf electroscope, to which we will impart a positive charge of electricity, and project the image of its divergent leaves on the screen. A poker, the tip of which has been made brightly red-hot, is placed so that its incandescent end is about an inch from the knob of the electroscope. No discharge takes place. Discharging the electroscope with my finger, I give it a small charge of negative electricity, and replace the poker in the same position. The gold leaves instantly collapse. Bear in mind that the extremity of the poker, when brought in contiguity to the knob of the charged electroscope, becomes charged by induction with a charge of the opposite sign to that of the charge of the electroscope, and you will at once see that this experiment confirms Prof. Guthrie's statement, for the negatively charged electroscope induces a positive charge on the incandescent iron, and this charge cannot be retained. If the induced charge on the poker is a negative charge, it is retained, and hence the positively charged electroscope is not discharged, but the negatively charged electroscope at once loses its charge. Pass in imagination from iron balls to carbon molecules. We may ask whether it is a legitimate assumption to suppose the same fact to hold good for them, and that a hot

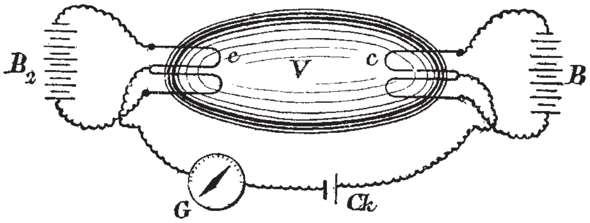

FIG. 13.—Vacuum tube having carbon loop electrodes, *c c*, at each end rendered incandescent by insulated batteries, B_1 B_2, showing current from Clark cell, *Ck*, passing through the high vacuum when the electrodes are incandescent.

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[1] "On a New Relation between Electricity and Heat," *Phil. Mag.*, vol. xlv. p. 308 (1873).

carbon molecule or small carbon mass just detached from an incandescent surface behaves in the same way and has a greater grip for negative than for positive charge? If this can possibly be assumed, we can complete our hypothesis as follows:—Consider a carbon molecule or small collection of molecules just set free by the high temperature from the negative leg of the incandescent carbon horseshoe. This small carbon mass finds itself in the electrostatic field between the branches of the incandescent carbon conductor (see Fig. 14). It is acted upon inductively, and if it behaves like the hot iron ball in Prof. Guthrie's experiment it loses its positive charge. The molecule then being charged negatively is repelled along the lines of electric force against the positive leg. The forces moving it are electric forces, and the repetition of this action would cause a torrent of negatively-charged molecules to pour across from the negative to the positive side of the carbon horseshoe. If we place a metal plate in their path, which is in conducting connection with the positive electrode of the lamp carbon, the negatively charged molecules will discharge themselves against it. A plate so placed may catch more or less of this stream of charged molecules which pour across between the heels of the carbon loop. There are many extraordinary facts, which as yet I have been able only imperfectly to explore, which relate to the sudden changes in the direction of the principal stream of these charged molecules, and to their guidance under the influence of magnetic forces. The above rough sketch of a theory must be taken for no more than it is worth, viz. as a working hypothesis to suggest further experiments.

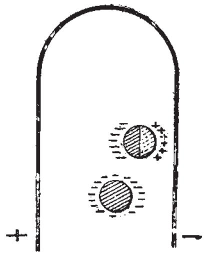

FIG. 14.—Rough diagram illustrating a theory of the manner in which projected carbon molecules may acquire a negative charge.

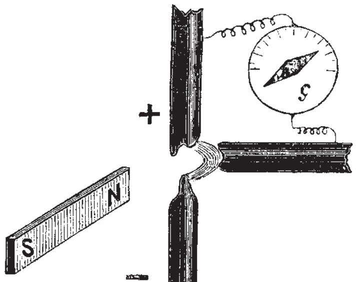

FIG. 15.—Electric arc projected by magnet against a third carbon, and showing a strong electric current flowing through a galvanometer, G, connected between the positive and this third carbon.

These experiments with incandescence lamps have prepared the way for me to exhibit to you some curious facts with respect to the electric arc, and which are analogous to those which we have passed in review. If a good electric arc is formed in the usual way, and if a third insulated carbon held at right angles to the other two is placed so that its tip just dips into the arc (see Fig. 15), we can show a similar series of experiments. It is rather more under control if we cause the arc to be projected against the third carbon by means of a magnet. I have now formed on the screen an image of the carbon poles and the arc between them, in the usual way. Placing a magnet at the back of the arc, I cause the flame of the arc to be deflected laterally and to blow against a third insulated carbon held in it. There are three insulated wires attached respectively to the positive and to the negative carbons of the arc, and to the third or insulated carbon, the end of which dips into the flame of the arc projected by the magnet. On starting the arc this third carbon is instantly brought down to the same electrical potential as the negative carbon of the arc, and if I connect this galvanometer in between the negative carbon and the third or insulated carbon, I get, as you see, no indication of a current. Let me, however, change the connections and insert the circuit of my galvanometer in between the positive carbon of the arc and the middle carbon, and we find evidence, by the violent impulse given to the galvanometer, that there is a strong current flowing through it. The direction of this current is equivalent to a flow of negative electricity from the middle carbon through the galvanometer to the positive carbon of the arc. We have here, then, the "Edison effect" repeated with the electric arc. So strong is the current flowing in a circuit connecting the middle carbon with the positive carbon that I can, as you see, ring an electric bell and light a small incandescent lamp when these electric-current detectors are placed in connection with the positive and middle carbons.

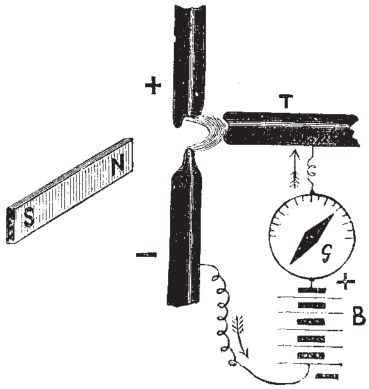

FIG. 16.—Galvanometer G and battery B inserted in series between negative carbon of electric arc and a third carbon to show unilateral conductivity of the arc between the negative and third carbons.

We also find that the flame-like projection of the arc between the negative carbon possesses a unilateral conductivity. I join this small secondary battery of fifteen cells in series with the galvanometer, and connect the two between the middle carbon and the negative carbon of the arc. Just as in the analogous experiment with the incandescent lamp, we find we can send negative electricity along the flame of the arc one way but not the other. The secondary battery causes the galvanometer to indicate a current flowing through it when its negative pole is in connection with the negative carbon of the arc (see Fig. 16), but not when its positive pole is in connection with the negative carbon. On examining the third or middle carbon after it has been employed in this way for some time, we find that its extremity is cratered out and converted into graphite, just as if it had been employed as the positive carbon in forming an electric arc.

Time forbids me to indulge in any but the briefest remarks on these experiments; but one suggestion may be made, and that is that they seem to indicate that the chief movement of carbon molecules in the electric arc is *from* the negative *to* the positive carbon. The idea suggests itself that, after all, the cratering out of the positive carbon of the arc may be due to a sand-blast-like action of this torrent of negatively charged molecules which are projected from the negative carbon. If we employ a soft iron rod as our lateral pole, we find that, after enduring for some time the projection of the arc against it, it is converted at the extremity into *steel*.

Into the fuller discussion as to the molecular actions going on in the arc, the source and nature of that which has been called the counter-electromotive force of the arc, and the causes contributing to produce unsteadiness and hissing in the arc, I fear that I shall not be able to enter, but will content myself with the exhibition of one last experiment, which will show you that a high vacuum, or, indeed, any vacuum, is not necessary for the production of the "Edison effect." Here is a carbon horseshoe-shaped conductor, not inclosed in any receiver (see Fig. 17). Close to the negative leg or branch, yet not touching it, we have adjusted a little metal plate. The sensitive galvanometer is connected between this metal plate and the base of the other or positive leg of this carbon arch.

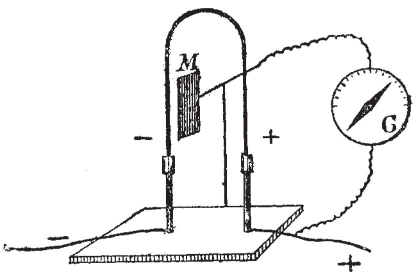

FIG. 17.—"Edison effect" experiment shown with carbon in open air.

On sending a current through the carbon sufficient to bring it to bright incandescence, the galvanometer gives indications of a current flowing through it, and as long as the carbon endures, which is not, however, for many seconds, there is a current of electricity through it equivalent to a flow of negative electricity from the plate through the galvanometer to the positive electrode of the carbon. The interposition of a thin sheet of mica between the metal plate and the negative leg of the carbon loop entirely destroys the galvanometer current.[1]

These experiments and brief expositions cover a very small portion of the ground which is properly included within the limits of my subject. Such fragments of it as we have been able to explore to-night will have made it clear that it is a region abounding in interesting facts and problems in molecular physics. The glow-lamp and the electric arc have revolutionized our methods of artificial lighting, but they present themselves also as subjects of scientific study, by no means yet exhausted of all that they have to teach.

NOTES.

PROF. E. RAY LANKESTER, F.R.S., has been elected Deputy Linacre Professor of Human and Comparative Anatomy, Oxford.

TO-DAY a meeting will be held at the Mansion House in support of the International Congress of Hygiene and Demography, which is to be held in London in 1891. The Prince of Wales has consented to act as President of the forthcoming Congress; and it is expected that the meetings will be "of great magnitude and importance." Many delegates have already been appointed, and other nominations are being received daily. It is necessary, therefore, that a definite organization should be formed, and that a fund should be raised for the defraying of expenses.

ON Wednesday next, July 9, Prof. T. McKenny Hughes F.R.S., will deliver a lecture in the saloon of the Mansion House on the question, "Is there coal in the south-east of England?" The Lord Mayor will preside, and will be supported by the "Coal Search Committee." This Committee has been formed for the purpose of taking steps to discover whether there really are good coal-fields in the south-east of England, and, if so, to what extent. It consists of scientific and commercial men, and their services are gratuituous. Among the members are Prof. Boyd Dawkins, Colonel Godwin-Austen, Prof. A. H. Green, Dr. Henry Hicks, Mr. W. H. Hudleston, Prof. Edward Hull, Dr. A. Irving, Prof. J. W. Judd, Sir John Lubbock, Prof. Meldola, Mr. F. W. Rudler, Prof. W. J. Sollas, Mr. J. J. H. Teall, Mr. W. Topley, Mr. W. Whitaker, and Dr. H. Woodward.

A NEW scientific Society (Die Deutsche zoologische Gesellschaft, on the lines of the Anatomische Gesellschaft) has just been founded. Early in May, nine representatives of zoology in German Universities issued a circular inviting brother zoologists to unite in forming a Zoological Society. On May 28 a preliminary meeting was held at Frankfurt, and zoologists from nearly a dozen German Universities were present. At present there are fifty-four members, and the next meeting is to be held on August 1, when a President will be chosen. The invitations to this meeting will be issued early in July. Applications for membership may be sent to Prof. Bütschli (Heidelberg), Prof. Victor Carus (Leipzig), or Prof. Spengel (Giessen). The foundation of this Society is a step in the right direction, and it is to be hoped that the new Zoologische Gesellschaft will speedily become as cosmopolitan as the sister anatomical one.

THE Norwegian Storthing, by 73 votes against 39, has voted a grant of 200,000 kroner for Dr. Nansen's North Pole Expedition.

THE third summer meeting of University Extension and other students will be held at Oxford in August next. The meeting will be divided into two parts. The first part of the meeting will begin with an inaugural address by Prof. Max Müller at 8.30 p.m. on Friday, August 1, and will end on Tuesday evening, August 12. The second part of the meeting will begin on Wednesday morning, August 13, and end on Tuesday evening, September 2. This period will be devoted to quiet study. The courses of lectures will be longer than those delivered during the first part of the meeting, and will deal in greater detail with the subjects then introduced.

SIR HENRY W. ACLAND has published a letter on "Oxford and Modern Medicine." It is addressed to Dr. James Andrew, and was printed originally for private circulation. In the preface the author expresses an earnest hope that "the broad and yet precise study of material science and of nature may prosper at Oxford, as part of the whole range of University thought, and that in the haste for technical education our physicians may not be relegated as some now desire into a professional class or clique by themselves, but be as formerly a living part of the whole of the scientific and literary University."

THE third International Shorthand Congress will be held at Munich from August 7 to 17. The centenary of F. X. Gabelsberger, the originator of modern German shorthand, will be celebrated by those who attend the meetings, and a bronze statue of him will be unveiled.

ACCOUNTS which have reached the *Times* from the Weatherby district, in Yorkshire, agree as to the occurrence of distinct earthquake shocks on Wednesday, June 25, about 10.30 p.m., and again on Thursday morning about four o'clock. Mr. John Emmet, of Boston Spa, sixteen miles from Leeds, states that shocks were experienced, not only at Boston Spa, but at Wighill, Clifford, Thorp Arch, Weatherby, and other places, and he

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[1] This last experiment is due to my assistant, Mr. A. H. Bate.